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ROYAL

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ESTABLISHMENT

BASIC RESEARCH AND WEAPON ASSESSMENT DIVISION

R.A.R.D.E. MEMORANDUM (B) 66/63

Trials to assess the lethality of a 76 mm HESH shell against armoured personnel carriers

R. Beresford

Fort Halstead
Kent.

December 1963

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ROYAL ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

R.A.R.D.E. MEMORANDUM (B) 66/63

Trials to assess the lethality of a 76 mm HESH shell against armoured personnel carriers

R. Beresford (B5)

1c c.74

Summary

The 76 mm gun at present in service in the Saladin armoured car has been considered as a possible solution to GSOR 1010 and GSOR 1012. When the assessment of lethality of the HESH round fired by this gun was started it was found that there was little information on its effects on AFV running gear (both wheels and tracks), on men in a confined space behind the armour plate, and on armoured engine compartments. This memorandum describes trials which were carried out on Daimler armoured cars and Comet tanks to obtain information on these points and summarises the results obtained.

Approved for issue:

L. Northcott

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INTRODUCTION

1. In February 1961, GSOR 1012, a requirement for a Vehicle Light Weapon System to defeat Armoured Personnel Carriers was published. Amongst other primary characteristics the system was required to have six successful engagements per minute against light A.F.V.s at 1,000 metres and to have maximum casualty effect against the crew and occupants of the vehicle.

2. The short list of possible solutions for the Requirement included the 76 mm gun at present in service in Saladin. When the detailed assessment of this weapon was started it was found that, although the plating performance of the HESH round was well established, little information was available regarding its effect against running gear, components behind armour, and on the effects of blast and fragments on men in a confined space.

3. A trial was therefore arranged to investigate these aspects of lethality: this memorandum describes the trial programme and the results obtained.

TRIAL PROGRAMME

4. It was decided that the trial should be made as comprehensive as possible and that vehicle targets should be used to simulate the eventual targets of the weapon. Accordingly a number of obsolete Daimler armoured cars and Comet tanks were used as targets, the latter to correspond to the Soviet tracked APC (BTR50p) and the former to give general information on attack of the APC crew compartment and effects against the type of wheels and suspension to be found in the new 8 wheeled APC (BTR60p). The trial was divided into two parts corresponding to the two targets concerned and all damage was evaluated on the spot by a team of assessors from F.V.R.D.E. and R.A.R.D.E. which included user representation. A summary of the plan and results is given in Appendix A. The target was photographed before and after each round; prints are shown in Appendix B for all rounds fired.

DAIMLER ARMOURED CAR TARGET

5. Three types of attack were considered, the effects of a near miss (blast and fragments) at various points round the vehicle, attack of wheels and associated components, and attack of the crew compartment.

Near Misses

6. Four rounds were fired as near misses, detonated on blocks of wood placed about two feet away from (a) the engine compartment, (b) a wheel, (c) the front centre of the vehicle, and (d) the up-armoured side of the car, with results as follows:

(a) The Engine Compartment (Figure 1). The outer plate (14 mm) was blown off but there was little damage either from fragments or blast except for an unimportant oil leak. The effect on Mobility was considered to be nil.

(b) Vehicle Front (Figure 2). Damage from many large fragments was apparent. Both tyres on the vehicle R.H.S. were punctured and a hydraulic leak was started. The Mobility loss was assessed at 25%.

(c) Wheels (Figure 3). The frame of the wheel was undamaged but large fragments stuck in the tyre casing would possibly have caused a puncture before the car had moved very far. The loss of Mobility was considered to be 5%.

(d) Car Side (Figure 4). There was no effect from fragments and little apparent damage from blast apart from a small fuel tank leak which was considered to have no effect on immediate Mobility.

Wheels and Suspension

7. Four rounds were fired at the running gear of the car, one at the front left wheel hub, one into the tyre in the plane of the wheel, one into the suspension between wheel and car body and finally, one into the wheel hub at 45° to the plane of the wheel.

(a) Wheel Hub (Figure 5). The wheel centre was totally destroyed and the tyre severely damaged.

Mobility loss = 95%.

(b) Tyre in Plane of Wheel (Figure 6). Wheel and tyre were destroyed and severe damage caused to the suspension.

Loss of Mobility = 100%.

(c) Suspension (Figure 7). The wheel was blown off and the suspension wrecked on the side concerned. No crew damage was apparent from blast and fragments but the effects of concussion would have been large.

Mobility loss = 100%.

(d) Wheel Hub at 45° to Wheel Plane (Figure 8). The wheel and tyre were severely damaged and removed from the suspension which was also damaged.

Loss of Mobility = 100%.

Crew Compartment

8. Three rounds were fired at the crew compartment with no success from the assessment aspect (Figures 9, 10 and 11). It had been hoped to simulate the APC crew compartment by up-armouring the plates on the car to about 1 inch thick (initially they were only 8 to 16 mm thick), but this could not be achieved. The car bodies were composed of a number of fairly small plates which did not provide sufficient support for the extra armour where the round struck. With each round the up-armouring weld did not hold on impact and the outer plate was driven through the main inner car plate and the round penetrated and detonated inside the car. Little useful information was obtained from these rounds other than confirmation that their effects in a confined space are more than adequate to immobilise the vehicle and incapacitate the crew.

Engine Compartment

9. Two rounds were fired into the engine compartment of the car, in the first case (a) into the side of the engine compartment through 9 mm plate and (b) into the rear of the compartment through plate up-armoured to 29 mm.

(a) Side of Engine Compartment (Figure 12). The round went through the 9 mm plate and detonated inside the compartment. The top cover was blown off and the engine severely damaged resulting in a complete loss of mobility.

(b) Rear of Compartment (Figure 13). This round was fired into up-armoured plate in the same way as the unsucoessful firings into the crew compartment, but against strengthened and rigidly clamped up-armouring. However, the results were as before. The welds and clamps broke, the top plate fractured, and the round detonated in the engine compartment with catastrophic results.

THE COMET TANK TARGET

10. Fourteen rounds were fired against this target, ten against running gear and engine to provide information on the attack of APC's, and the remainder, four, against turret and gun to fill gaps in the general picture of information on lethality against tank targets.

Engine Compartment

11. Two rounds were fired into the engine compartment from the rear protected by two different thicknesses of plate.

(a) Hull Rear Lower Plate. 32mm/18° (Figure 14). The rear plate was holed and scabbed, the gearbox perforated by fragments and the hydraulic pipes to the brakes cut.

Mobility loss = 100%.

(b) Hull Rear Upper Plate. 25 mm/0° (Figure 15). The rear plate was holed and the resulting scab broken into fragments by a strut immediately behind the plate. The gearbox was destroyed and the coolant pipe and header tank holed. The loss in Mobility was 100%. and there would have been a 10% reduction in Fire-power capability.

Running Gear

12. Eight rounds in all were fired at the tank running gear, at various road wheels, drive and idler sprockets and tracks as follows:

(a) Centre Road Wheel Rim (Figure 16). The wheel rim was severely damaged and two of the roller guides were removed. The tank was still capable of reduced movement.

Loss of Mobility = 10%.

(b) Front Road Wheel Hub (Figure 17). The wheel hub and rim were severely damaged but the tank was still capable of reduced movement.

Loss of Mobility = 15%.

(c) Rear Road Wheel Rim (Figure 18). The wheel rim and hub were extensively damaged.

Loss of Mobility = 10%.

(d) Idler Wheel Hub (Figure 19). The idler was destroyed for half its circumference.

Loss of Mobility = 100%.

(e) Rear Sprocket Wheel (Figure 20). The round struck between hub and rim and damaged both, knocking teeth out of the rim. One roller guide, already loosened by a previous round, was detached.

Loss of Mobility = 90%.

(f) Track Edge (Figure 21). The track was one-third severed and a guide roller removed.

Loss of Mobility = 5%.

(g) Track over Idler Wheel (Figure 22). The round struck the track at 90° to its plane and oompletely severed it, severely damaging the idler wheel.

Loss of Mobility = 100%.

(h) Track between Idler and Road Wheel (Figure 23). The round hit the track at 45° to its plane and completely out it, removing the idler at the same time.

Loss of Mobility = 100%.

Gun Mechanism

13. Doubt has existed in the past about the effect of a hit on the gun mantlet It was not expected that a scab would occur, especially with a small round such as the 76 mm HESH, but it was felt that damage to the gun elevating mechanism and sighting apparatus might occur; during the present trial an opportunity arose to examine this. A round was fired at the mantlet, striking at a point about eighteen inches from the barrel (Figure 24). It was found that after the impact the gun could still be elevated and depressed, if a little more slowly than before, and that a rough lay with the sighting telescope, checked before and after the impact, remained unchanged. There were, however, obvious effects of concussion inside the hull and turret of the tank, and the driver and loader would probably have been affected by blast with a possible reduction in Mobility of 80% and in Fire-power of 50%.

Turret Traverse

14. In discussions on anti-tank projectile lethality, there have been differences of opinion regarding the effeot of a nearby hit on the turret traversing mechanism of a tank. Since at the end of the present trial there was spare ammunition and a suitable target available, it was decided to investigate this question and several others on which information was lacking. Accordingly a round was fired at the plate skirting the turret ring of the Comet tank (Figure 25). On examination of the turret interior, it was found that the plate had scabbed and that damage to the dummies placed in the turret to simulate crew members showed that the turret crew would have been incapacitated. Damage to the gun and associated equipment from blast and the scab had made it unserviceable. The resulting loss in Mobility was 65% and in fire power 100%. Regarding the mechanical condition of the tank, it is worth recording that the hand-traversing mechanism of the turret was still in working order although a little stiffer than before the attack.

Effect of External Equipment on Fuze Performance

15. One of the uncertainties in lethality assessment in the past has been the effeot of external equipment such as tool bins on the fuze performance of HESH projectiles. Accordingly a round was fired at the rear of the Comet turret, aimed to hit the rear stowage bin before striking the main armour of the turret (Figure 26), giving a distance of 18 in. between bin and plate; the bin was empty. It was found that the performance of the fuze was unaffected by the wall of the bin (⅛ in. mild steel); the plate (57 mm/0°) was scabbed, and the dummies indicated that the turret crew would have been incapacitated. The Mobility loss was assessed at 65% and the Fire-power loss at 100%.

Effect on Main Turret Armour

16. A further round was fired at the side of the Comet turret (64 mm/0°) to provide straightforward information on blast and scab damage inside an enclosed armoured compartment (Figure 27). The plate scabbed and from the resulting damage it was concluded that the gun was rendered unserviceable and the turret crew would have been killed, resulting in a 65% loss of Mobility and 100% loss of firing capability.

CONCLUSIONS

17. From the results of the trial the following conclusions may be drawn for the 76 mm HESH projectile.

Running Gear: Tracked Vehicle

A hit edge-on on the track diminishes Mobility by 5% only, whereas a hit in the plane of the track cuts it and completely immobilises the vehicle. A hit on any of the road wheels reduces Mobility by 10-15%, for the vehicle is still capable of reduced movement. Hits on either the front idler or the drive sprocket virtually immobilise the vehicle.

Running Gear: Wheeled Vehicles

A strike anywhere on the wheel, from hub to tyre and on the suspension, causes 100% Mobility damage in almost every oase.

Engines

A hit anywhere on the engine compartment causes oomplete immobilisation of the vehicle, either by detonation after passing through thin armour plate or from scabbing thicker plate up to the critical thickness for this round (90 mm/0°).

Crew Compartment

There is adequate evidence both from this and other trials that the effect of the 76 mm. HESH round is catastrophic inside a closed compartment whether it detonates after penetrating thin armour or scabs thicker plate.

Near Misses

A near miss at a distance of about two feet has no effect on the body of an armoured vehicle, but can cause a reduction in Mobility in wheeled vehicles of up to 25% by means of punctures in the tyres.

General

A detonation on the gun mantlet will have little effect on the gun elevating gear and sighting mechanism, but will most probably cause a reduction of up to 50% in Fire power and 80% in Mobility owing to ooncussive effects on the crew. A hit on the plate skirting the turret ring can immobilise the tank by scabbing the plate and hence killing the crew, but can leave the mechanism almost undamaged. The effect of external barriers, such as empty tool bins, will have no effect on round performance against the plate behind the barrier.

ACKNOWLEDGEMENTS

18. Grateful acknowledgements are made to Mr. E. Champion of the Research Trials Group, FVRDE, for his arrangement of the trial and for his help in its execution and in the assessment of results. The co-operation and assistance of Lt. Col. R.R. Moss, M.C., R.Tks., and Captain R.S.M. Green, 16th/5th Queen's Royal Lancers, of the Armaments Wing, FVRDE, Kirkcudbright, is also gratefully acknowledged.

APPENDIX A

Summary of points of strike and resulting damage

DAIMLER ARMOURED CAR TARGET		
Round No.	Location of strike	Damage
1.	Wood block 2 ft. from engine.	Rear plate blown off but otherwise little damage. Effect on Mobility = zero.
2.	Wood block 2 ft. from vehicle front.	Two tyres punctured and hydraulic leak started. Mobility loss = 25%
3.	Wood block 2 ft. from wheel.	Wheel frame undamaged but large splinters present in tyre. Mobility loss = 5%
4.	Wood block close to armoured side of car.	No damage other than small fuel leak which would have no immediate effect.
5.	Wheel hub	Wheel centre destroyed and tyre damaged. Mobility loss = 95%
6.	Tyre in plane of wheel.	Wheel and tyre destroyed. Severe damage to suspension. Mobility loss = 95%
7.	Suspension	Wheel blownoff and suspension wrecked. Mobility loss = 100%
8.	Wheel hub at 45° to wheel plane.	Wheel and tyre damaged and blown off. Suspension wrecked. Mobility loss = 100%
9.	0° into front plate (7 mm armour).	Round penetrated and burst inside car.
10.	Repeat of 9 up-armoured to 26 mm.	Plate driven back through basic armour. Round detonated inside car. Unsatisfactory.
11.	Turret-side up-armoured to 35 mm armour/65° to normal.	Hole torn, up-armouring weld did not hold. Round burst in car. Unsatisfactory.
12.	Engine compartment side (9 mm armour).	Round penetrated and detonated inside compartment. Engine severely damaged.
13.	Engine compartment rear (29 mm armour).	Up-armouring welds broke and round again detonated in engine compartment. Mobility loss = 100%

"C O M E T" T A N K T A R G E T					
Round No.	Location of strike	Damage	Loss per cent		
			M	F	K
1.	Hull rear lower plate (32 mm/18°).	Plate holed and scabbed. Gear-box holed. Hydraulics damaged.	100	-	-
2.	Hull rear upper plate (25 mm/0°).	Plate holed, gearbox smashed, coolant pipe and header tank holed.	100	10	-
3.	Centre road wheel rim	Wheel severely damaged, two roller guides removed.	10	-	-
4.	Front road wheel hub	Hub damaged but tank capable of reduced movement.	15	-	-
5.	Rear road wheel rim	Rim and hub severely damaged .	10	-	-
6.	Idler wheel hub	Idler severely damaged.	100	-	-
7.	Rear sprocket wheel	Hub damaged, teeth out of rim.	90	-	-
8.	Track edge	Track one third severed and a guide roller removed.	5	-	-
9.	Track over idler	Track severed. Idler severely damaged.	100	-	-
10.	Track between idler and road wheel.	Track severed. Idler removed.	100	-	-
11.	Mantlet (102 mm/0°)	Little mechanical effect. Driver and loader probably affected by blast.	80	50	-
12.	Turret skirt (64mm/0°)	Turret armour scabbed. Gun U/S. Turret crew incapacita-ted. Traverse mechanism O.K.	65	100	-
13.	Turret stowage bin (Empty) (57 mm/0°)	Turret armour scabbed. Turret crew incapacitated.	65	100	-
14.	Turret side. (64 mm/0°)	Armour scabbed. Gun U/S Turret crew incapacitated.	65	100	-

APPENDIX B

Photographic Record of the Trial

1. The first figure shows the target before being attacked. The point of aim is marked either with a cross or a white spot.

2. The second figure(s) shows the target after being attacked.

FIG.1

FIG. 1 NEAR MISS CLOSE TO THE ENGINE COMPARTMENT

FIG. 2

FIG. 2 NEAR MISS CLOSE TO THE FRONT OF THE VEHICLE

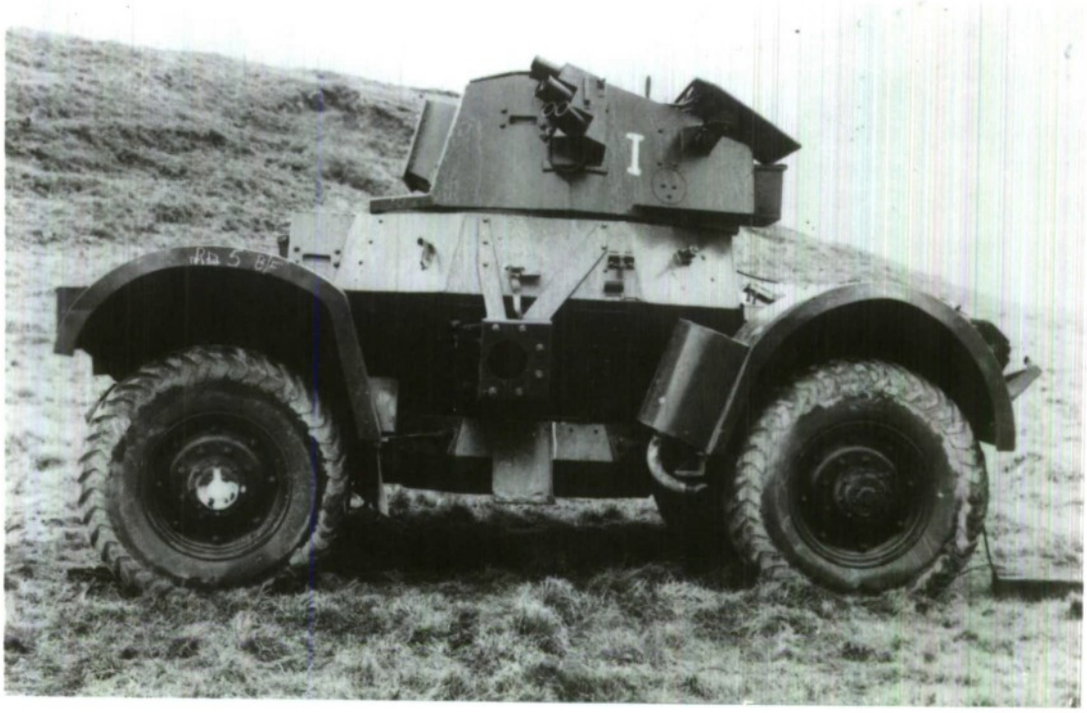
FIG. 3

FIG. 3 NEAR MISS CLOSE TO A WHEEL

FIG. 4

FIG. 4 NEAR MISS CLOSE TO CAR SIDE

FIG. 5



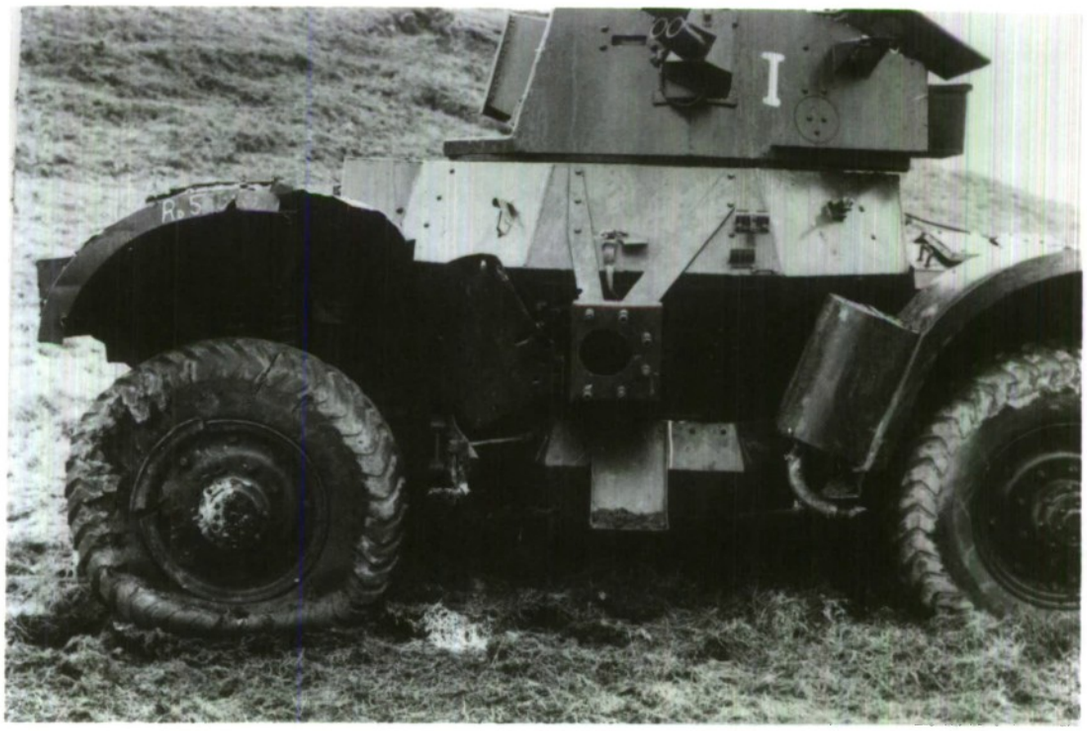
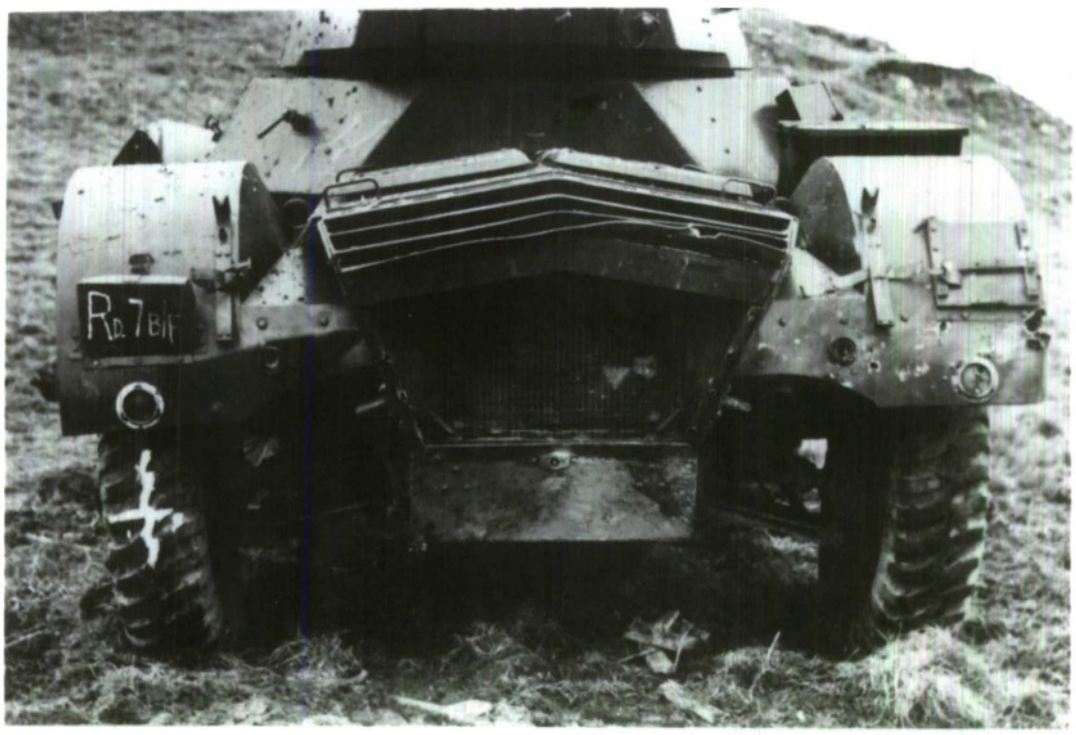


FIG. 5 DIRECT HIT ON WHEEL HUB

FIG. 6



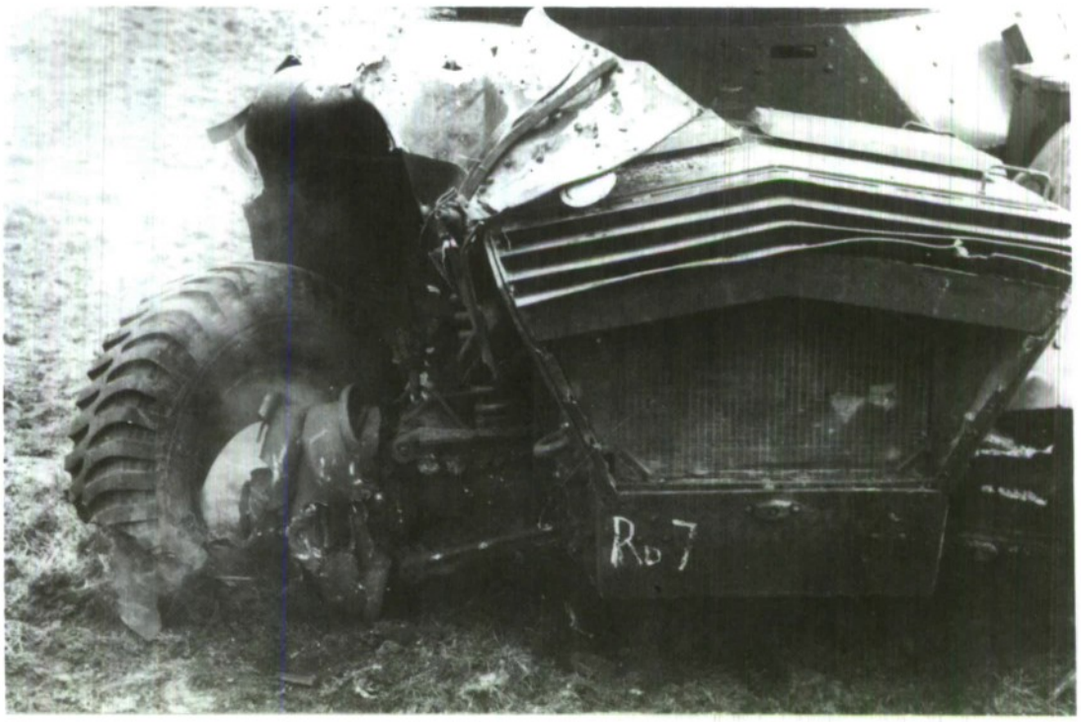


FIG. 6 DIRECT HIT ON TYRE

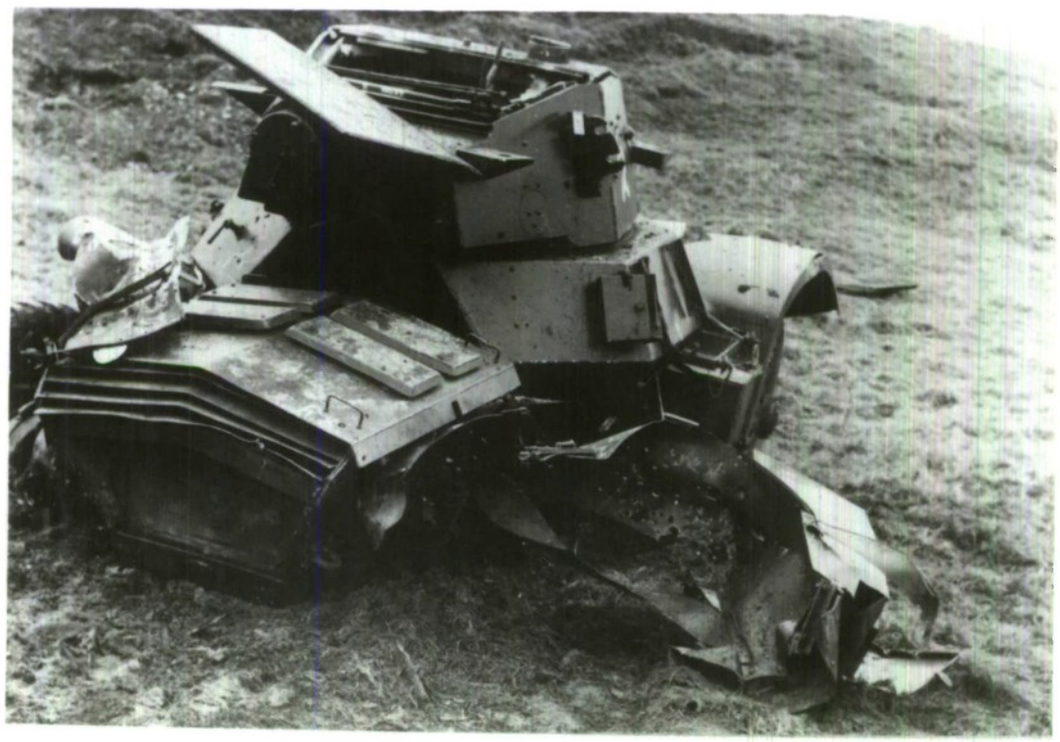


FIG. 7 DIRECT HIT ON SUSPENSION

FIG. 8 DIRECT HIT ON WHEEL HUB

FIG. 9

FIG. 9 DIRECT HIT ON CREW COMPARTMENT

FIG. 10

FIG. 10 DIRECT HIT ON CREW COMPARTMENT

FIG. 11

FIG. 11 DIRECT HIT ON CREW CONPARTMENT

FIG. 12 DIRECT HIT ON SIDE OF ENGINE COMPARTMENT

FIG. 13

FIG. 13 DIRECT HIT ON REAR OF ENGINE COMPARTMENT

FIG. 14

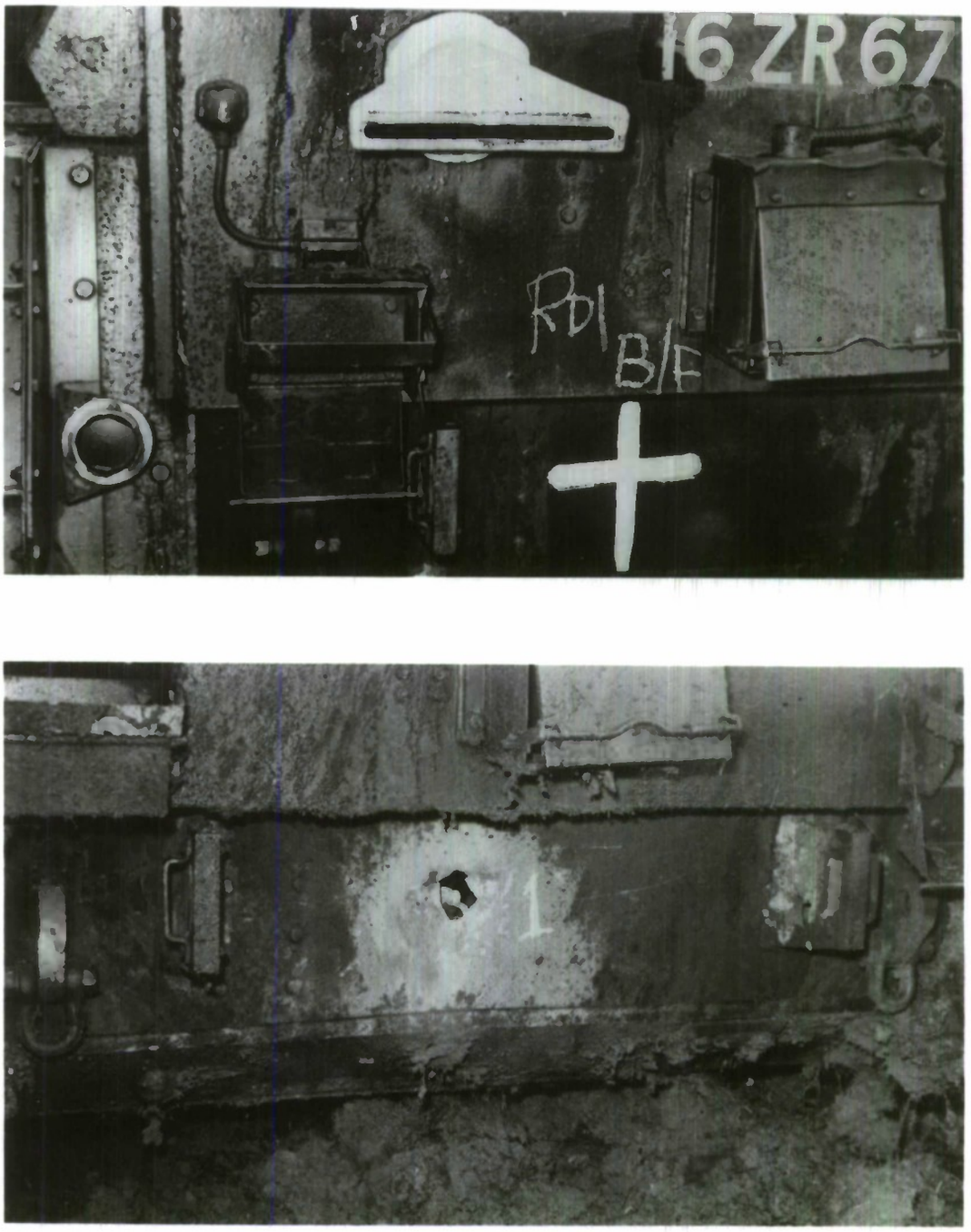


FIG. 14 DIRECT HIT ON REAR HULL PLATE

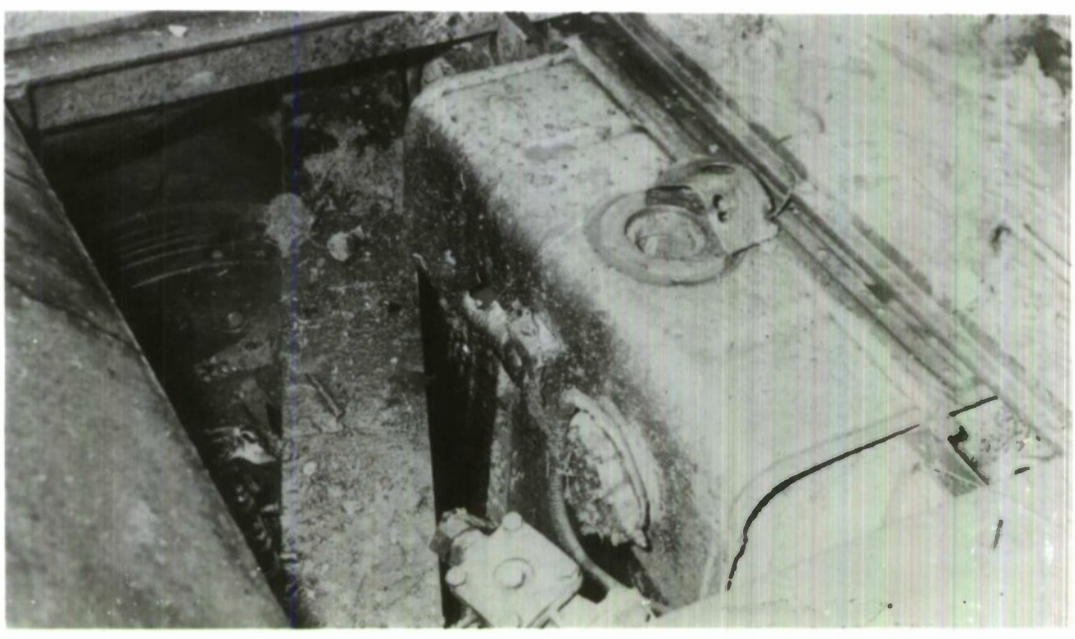


FIG. 15 DIRECT HIT ON REAR UPPER PLATE

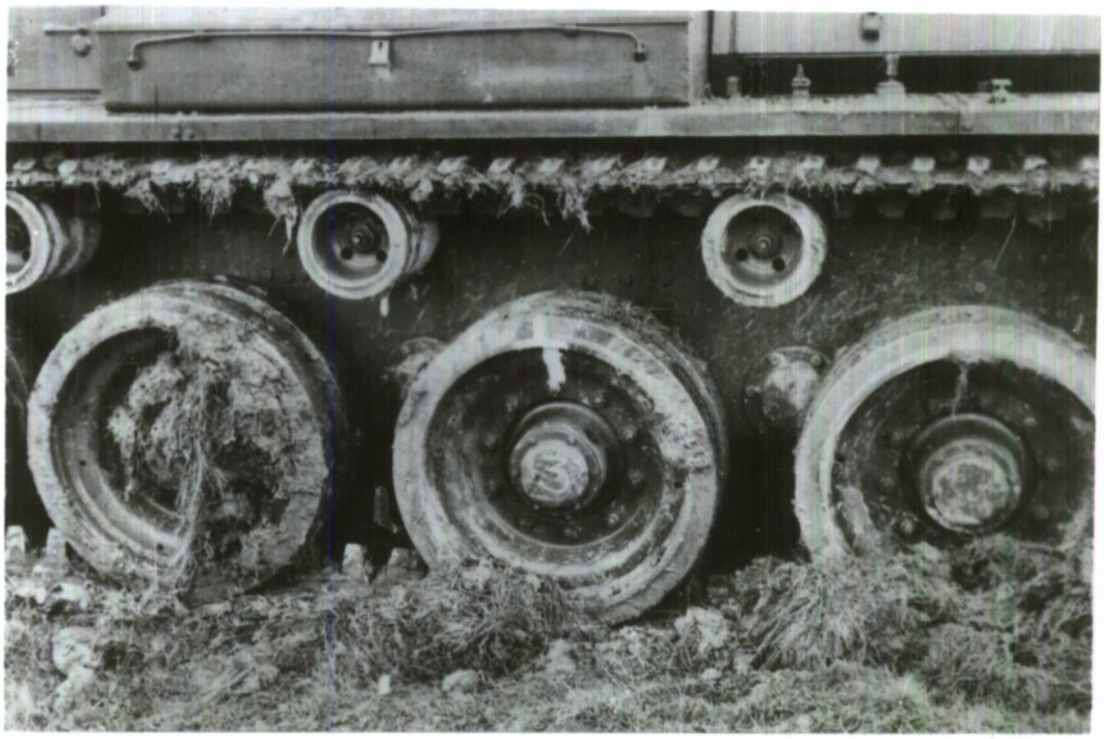


FIG. 16 DIRECT HIT ON CENTRE ROAD WHEEL RIM

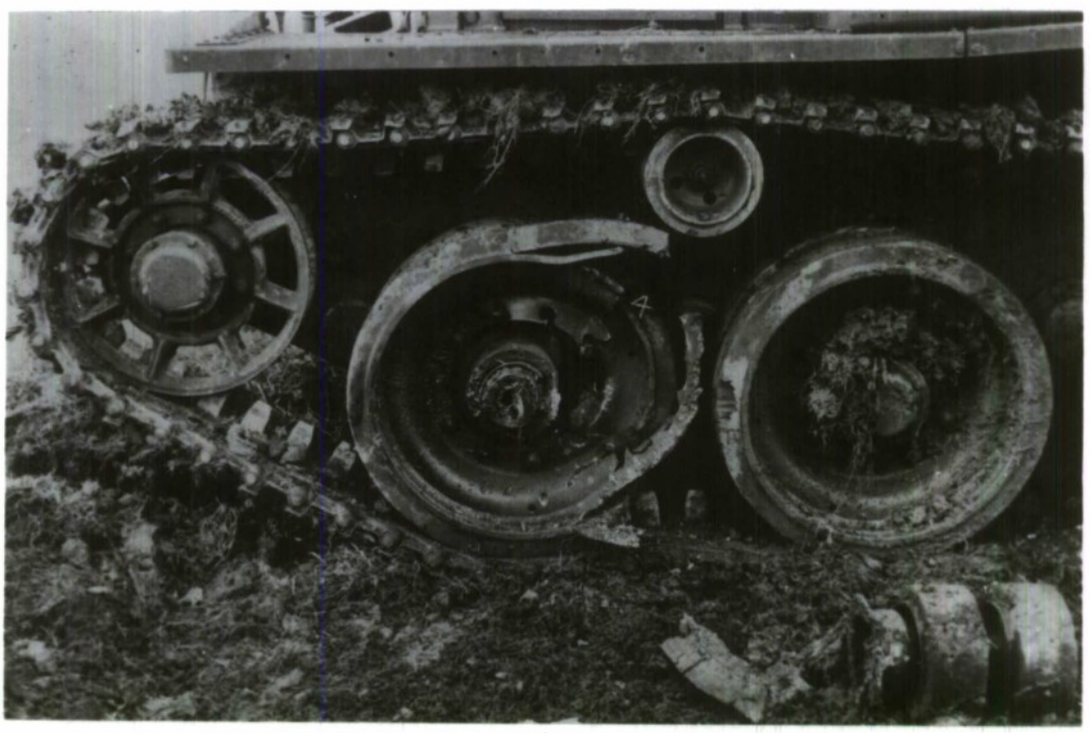
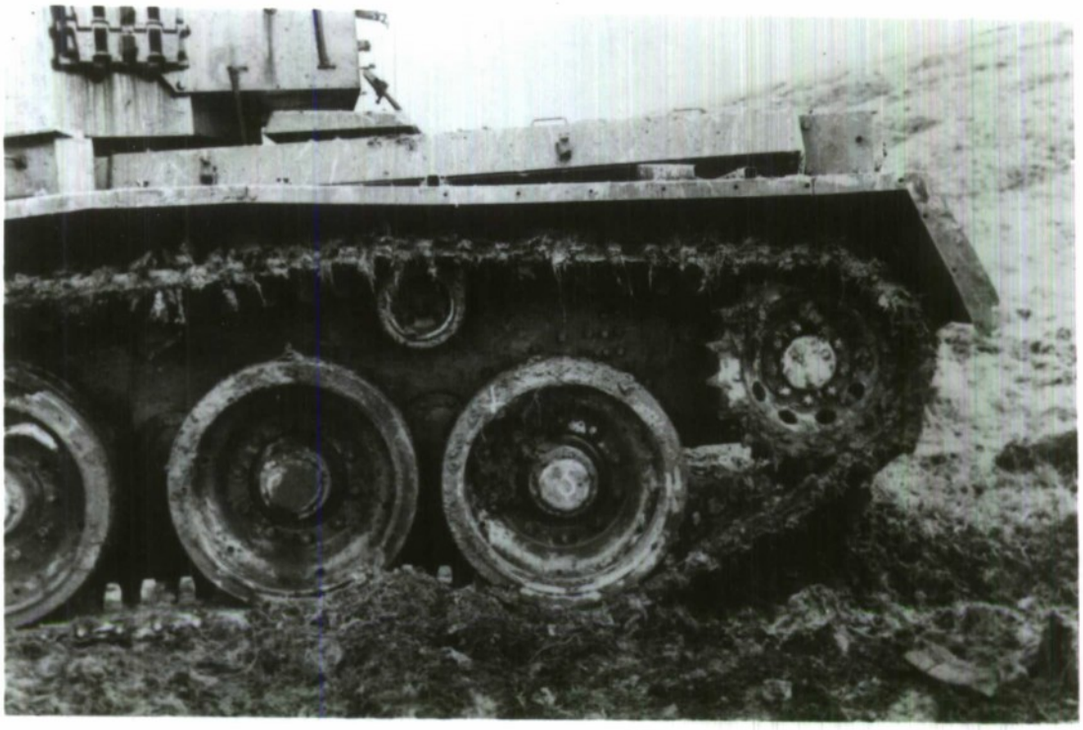


FIG. 17 DIRECT HIT ON FRONT ROAD WHEEL HUB



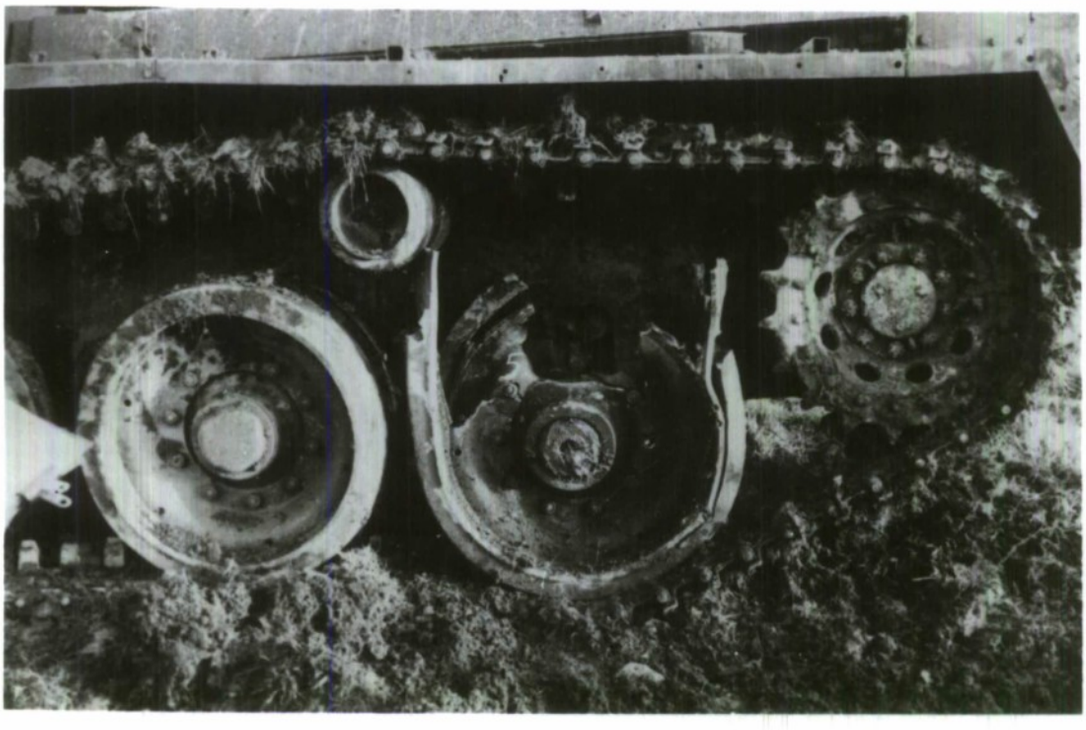
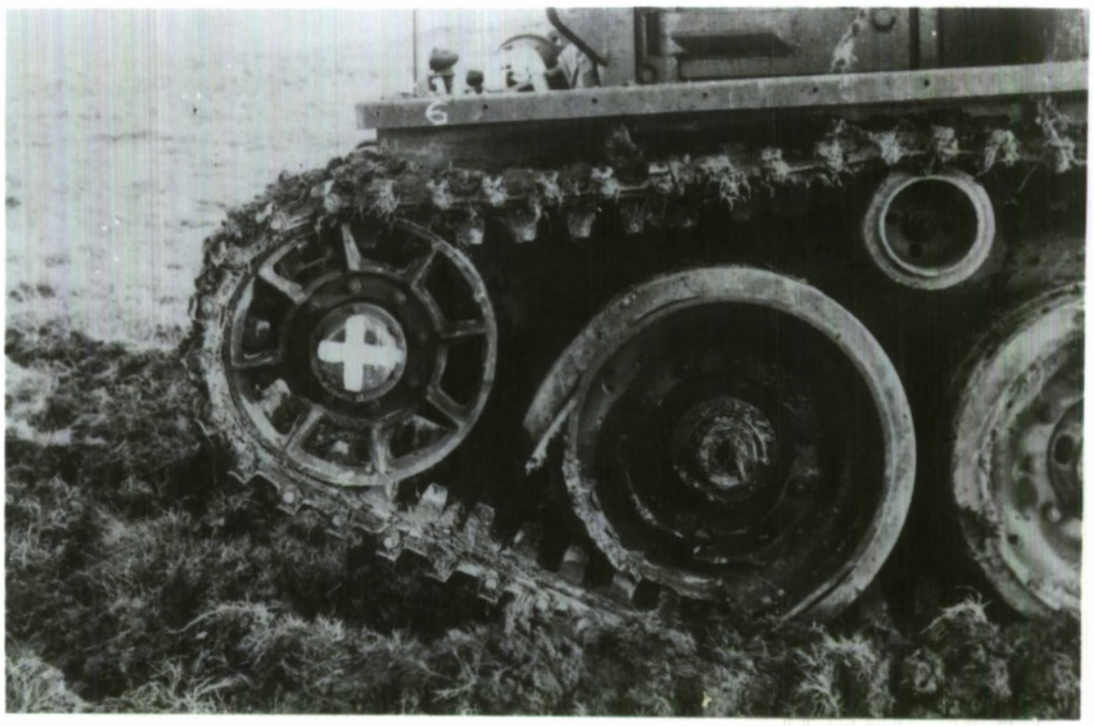


FIG. 18 DIRECT HIT ON REAR ROAD WHEEL RIM



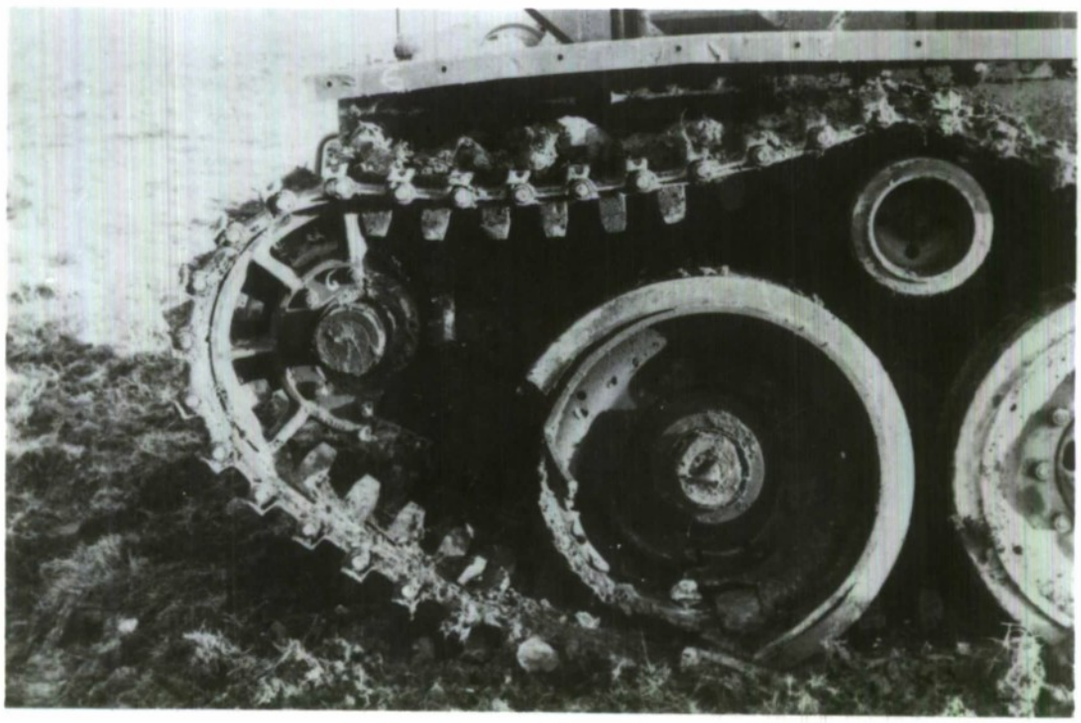
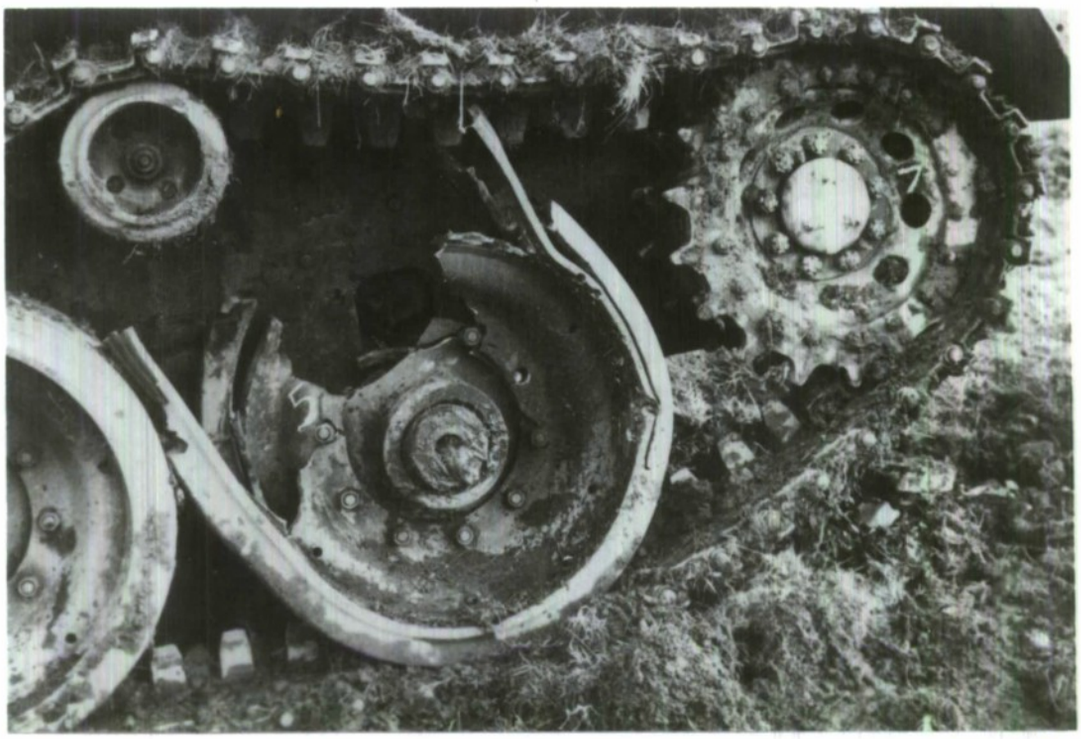


FIG. 19 DIRECT HIT ON IDLER WHEEL HUB



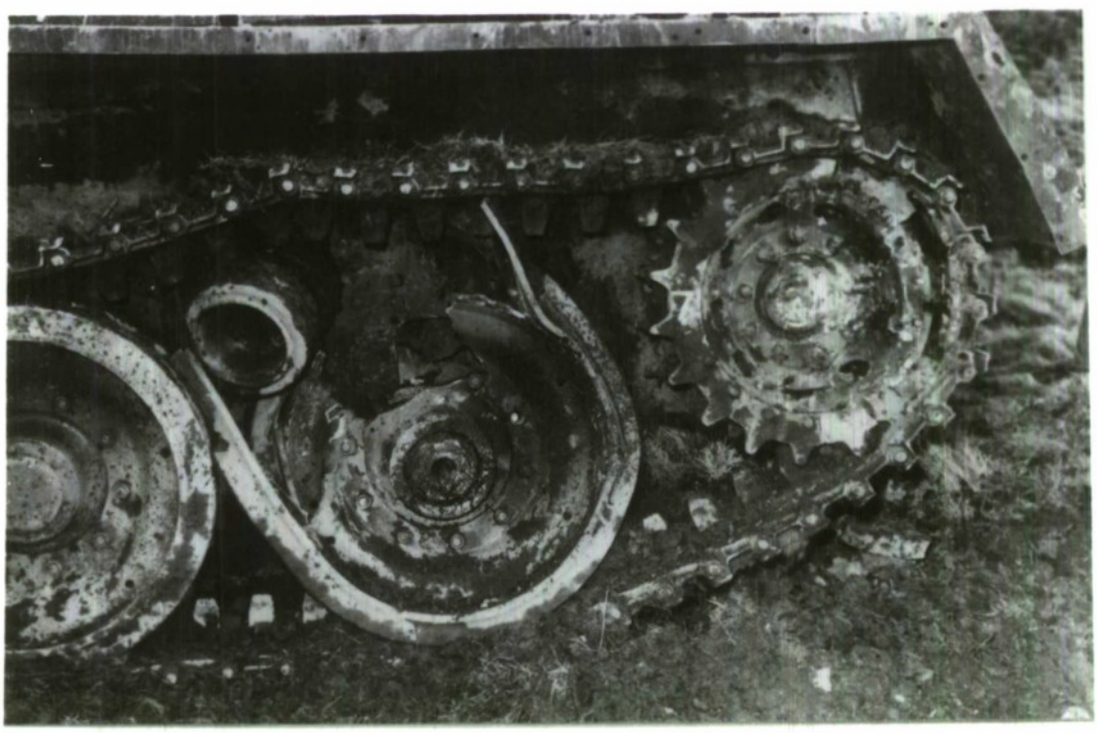
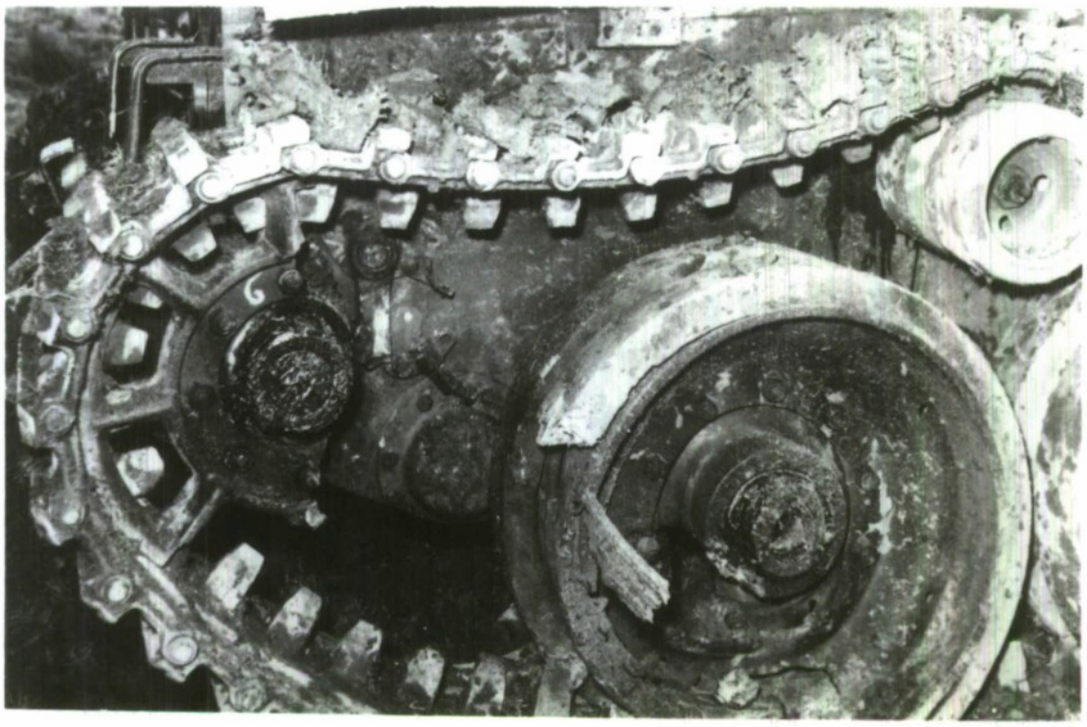


FIG. 20 DIRECT HIT ON REAR SPROCKET WHEEL



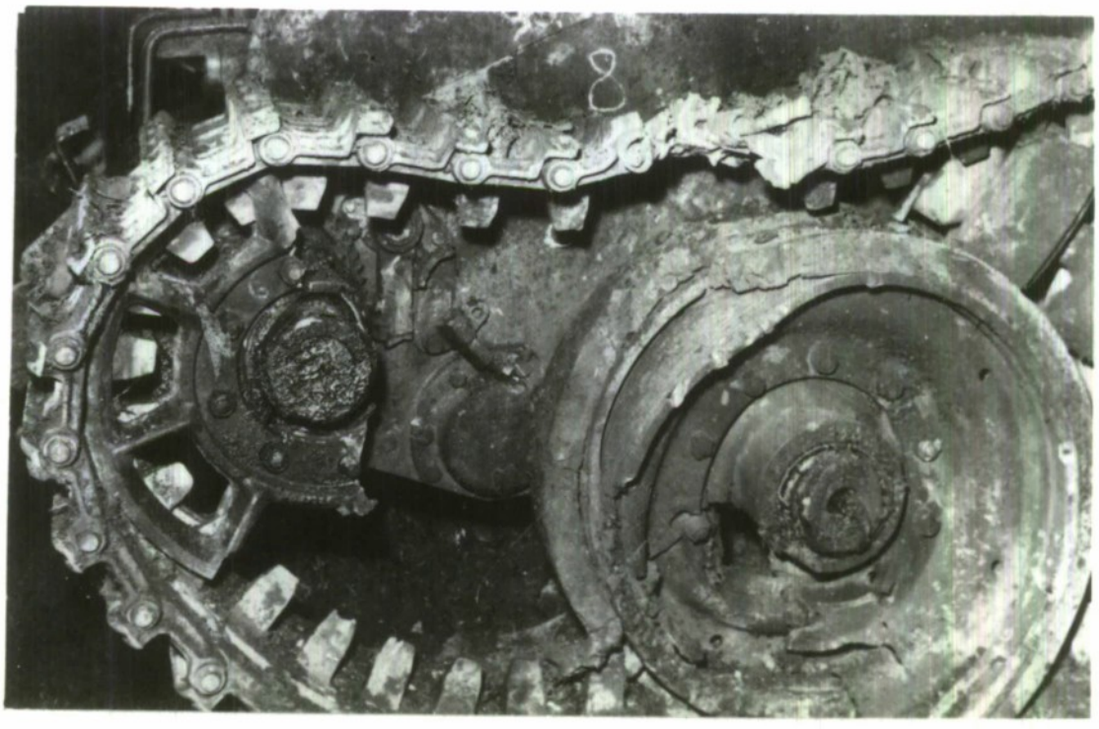


FIG. 21 DIRECT HIT ON TRACK EDGE

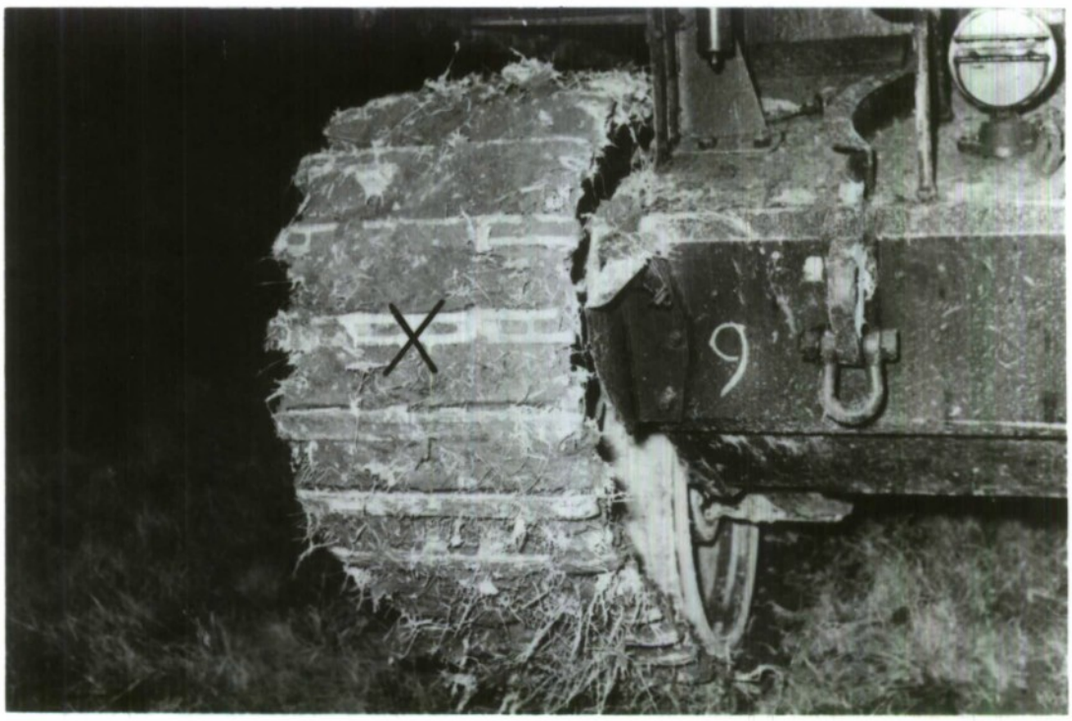


FIG. 22 DIRECT HIT ON TRACK OVER IDLER

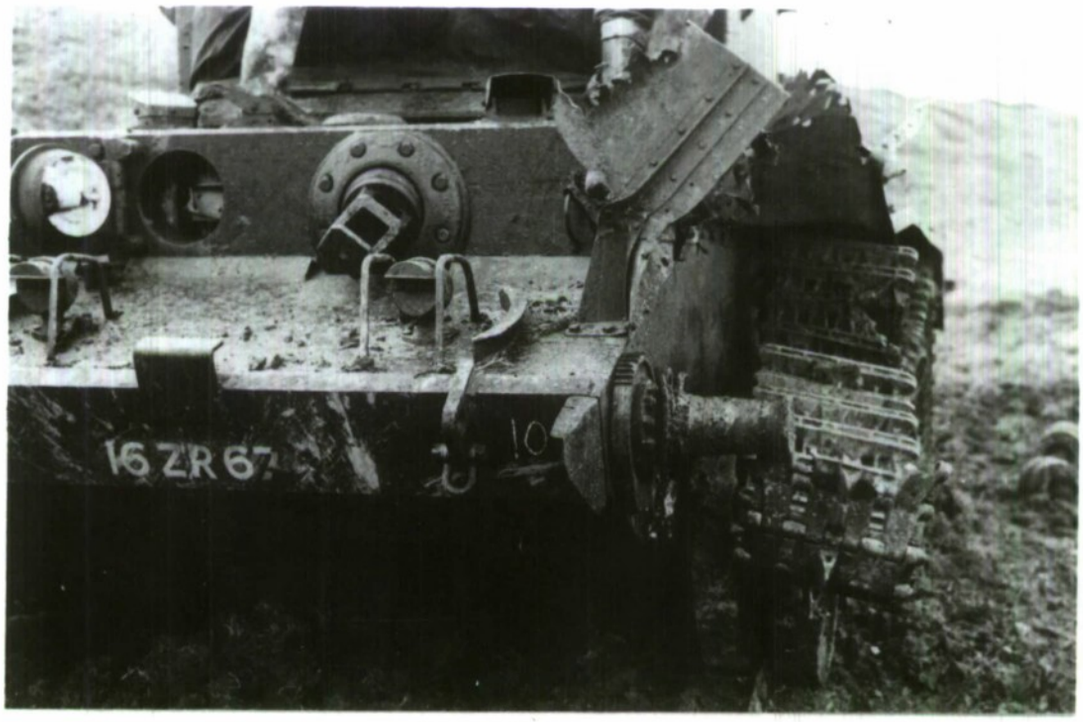


FIG. 23 DIRECT HIT ON LOWER TRACK

FIG. 24

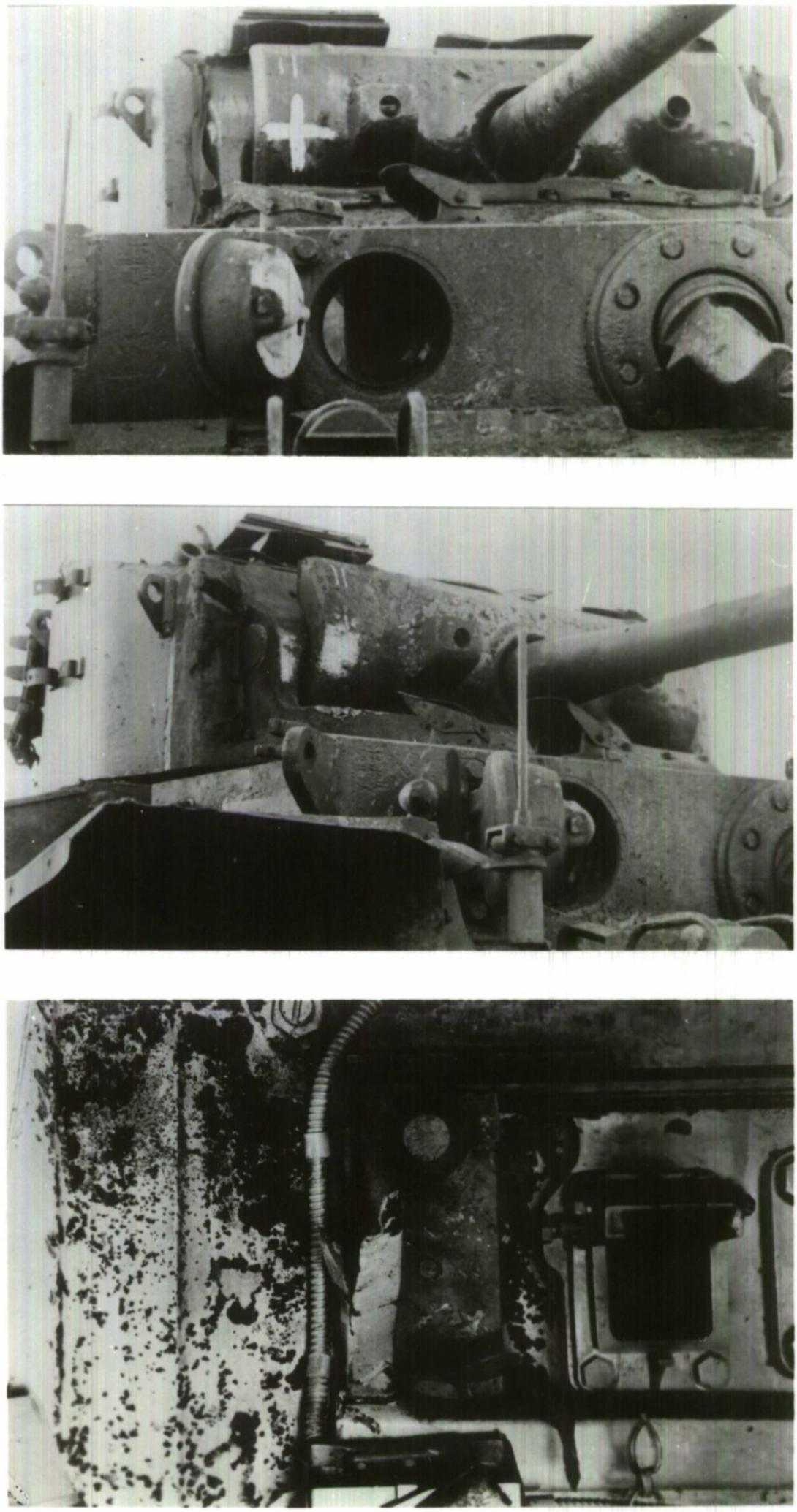


FIG. 24 DIRECT HIT ON MANTLET

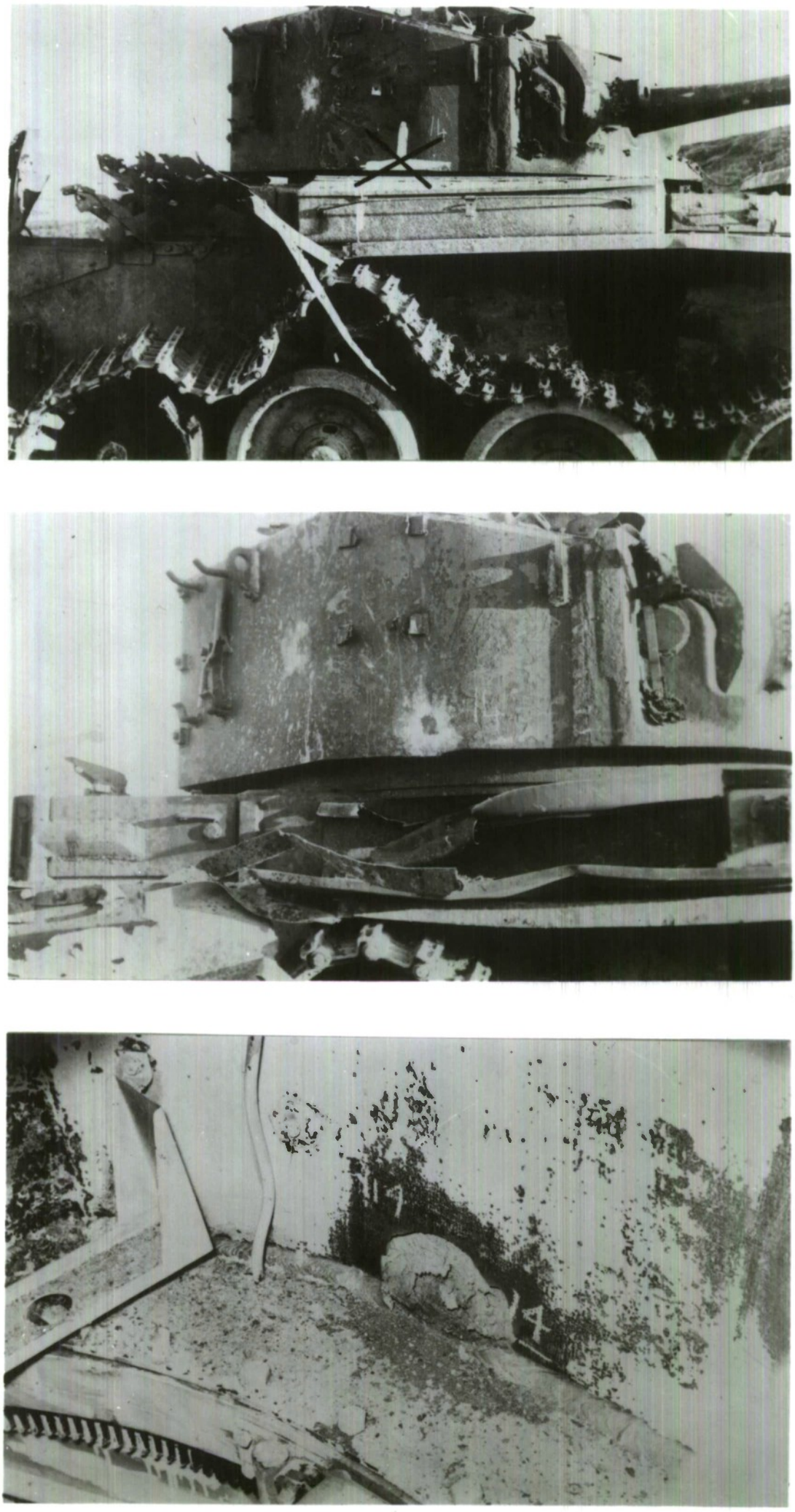
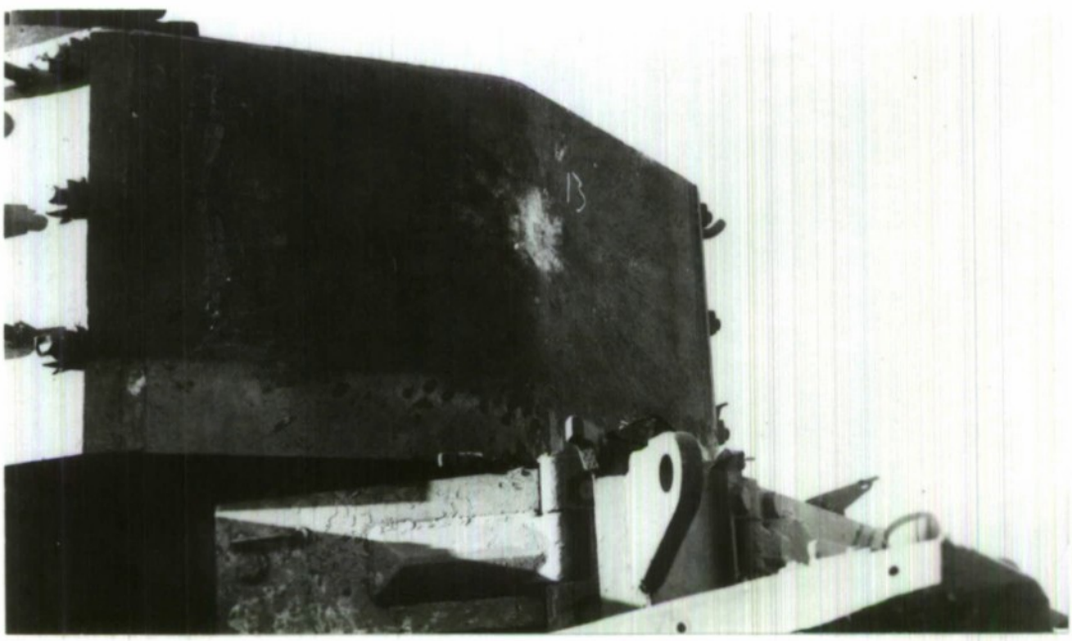


FIG. 25 DIRECT HIT ON PLATE OVER TURRET RING



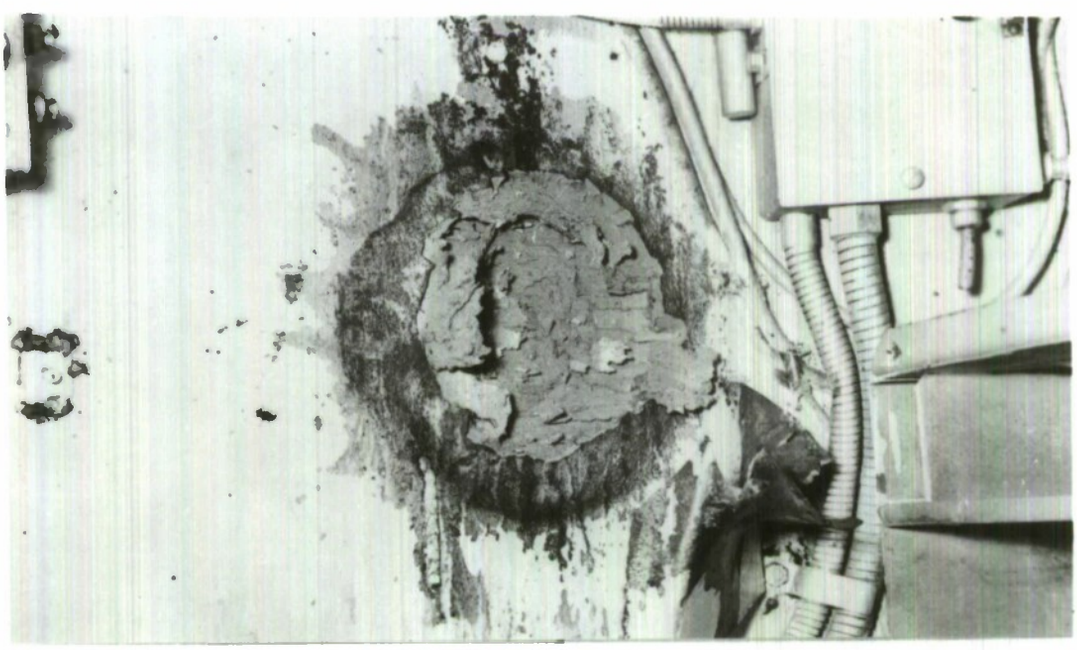


FIG. 26 DIRECT HIT ON STOWAGE BIN

FIG. 27

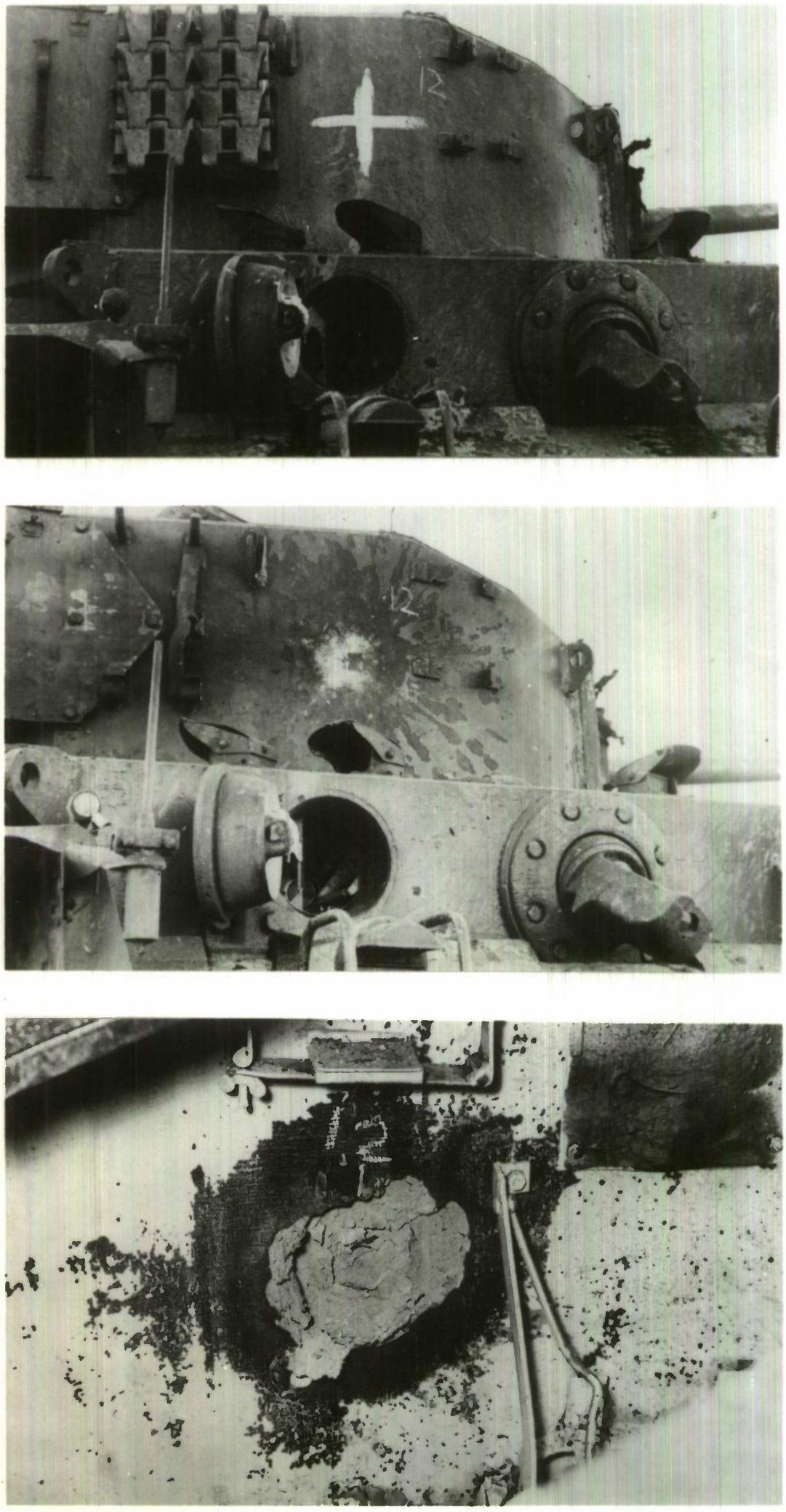


FIG. 27 DIRECT HIT ON TURRET SIDE ARMOUR

For Indexing

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Royal Armament Research and Development Establishment | 623.451.42 '76mm':
R.A.R.D.E. Memorandum (B)66/63 | 623.562.5: 623.438.1

Trials to assess the lethality of a 76 mm HESH shell against armoured personnel carriers.
R. Beresford

December 1963

The 76 mm gun at present in service in the Saladin armoured car has been considered as a possible solution to GSOR 1010 and GSOR 1012. When the assessment of lethality of the HESH round fired by this gun was started it was found that there was little information on its effects on AFV running gear (both wheels and tracks), on men in a confined space behind the armour plate, and on armoured engine compartments. This memorandum describes trials which were carried out on Daimler armoured cars and Comet tanks to obtain information on these points and summarises the results obtained.

9 pp. 27 figs. 1 tab.

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